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PATENT **00RE089**

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Himanshu S. Amin

In The United States Patent And Trademark Office

In re patent application of:

Applicant(s): Frederick M. Discenzo

Serial No: 09/625,094

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Examiner: Hwa S. Lee

Art Unit: 2877

Title: SYSTEM FOR MONITORING BEARING WEAR

Mail Stop Appeal Brief – Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Appeal Brief

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Dear Sir:

Applicant's representative submits this brief in connection with an appeal of the above-identified patent application. A credit card payment form is filed concurrently herewith in connection with all fees due regarding this appeal brief. In the event any additional fees may be due and/or are not covered by the credit card, the Commissioner is authorized to charge such fees to Deposit Account No. 50-1063 [ALBRP178US].

I. Real Party in Interest (37 C.F.R. §41.37(c)(1)(i))

The real party in interest in the present appeal is Reliance Electric Technologies, LLC, the assignee of the present application.

II. Related Appeals and Interferences (37 C.F.R. §41.37(c)(1)(ii))

Appellant, appellant's legal representative, and/or the assignee of the present application are not aware of any appeals or interferences which may be related to, will directly affect, or be directly affected by or have a bearing on the Board's decision in the pending appeal.

III. Status of Claims (37 C.F.R. §41.37(c)(1)(iii))

Claims 22, 23, and 28-36 have been cancelled. Claims 1-21, 24-27, and 37-43 stand rejected by the Examiner. The rejection of claims 1-21, 24-27, and 37-43 is being appealed.

IV. Status of Amendments (37 C.F.R. §41.37(c)(1)(iv))

No claim amendments have been entered after the Final Office Action.

V. Summary of Claimed Subject Matter (37 C.F.R. §41.37(c)(1)(v))

A. Independent Claim 1

Independent claim 1 recites a system for determining at least one condition of a bearing, comprising at least one optical fiber embedded in a bearing, the at least one optical fiber being adapted to transmit light from a light source, and an interferometric system operatively coupled to the optical fiber and a processor, wherein the interferometric system provides the processor with information relating to at least one condition of the bearing, and the processor determines a state of the at least one condition of the bearing based on the information. (*See e.g.*, page 8, fourth full paragraph).

B. Independent Claim 16

Independent claim 16 recites a system for determining at least one condition of a bearing, comprising a light source for generating a beam of light, at least one optical fiber at least part of which is embedded in a bearing, the at least one optical fiber having first and second ends, the first end receiving the beam of light, the second end being flush with a contacting surface of the bearing, and a measuring system operatively coupled to the optical fiber, wherein the optical fiber provides the measuring system with information relating to the at least one condition of the bearing. (*See e.g.,* pages 8-9, connecting paragraph).

C. Independent Claim 24

Independent claim 24 recites a method for determining at least one condition of a bearing, comprising the steps of providing a bearing having an optical fiber embedded therein, using a measuring system operatively connected to the optical fiber to collect information relating to the optical fiber, and using a processor operatively coupled to the measuring system to determine the at least one condition of the bearing based on the information. (*See e.g.,* page 9, first full paragraph).

D. Independent Claim 37

Independent claim 37 recites a system for determining at least one condition of a bearing, comprising at least one optical fiber embedded in a bearing, the at least one optical fiber being adapted to transmit light from a light source, an interferometric system operatively coupled to the optical fiber and a processor, the interferometric system comprising optics and a detector, the light source transmitting light from the light source to the at least one fiber which is reflected from the optics to the detector, and an actuator coupled to the processor and the optics wherein the processor controls the actuator to adjust the optics based on at least one condition of the bearing. (*See e.g.,* page 8, fourth full paragraph, Fig. 3, reference numeral 70).

VI. Grounds of Rejection to be Reviewed (37 C.F.R. §41.37(c)(1)(vi))

A. Claims 1-12, 14-21, and 24-27 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Dunphy, *et al.* (US 5,399,854) in view of Kersey, *et al.* (US Patent 5,361,130) and Thomas, *et al.* (US 4,460,893).

B. Claims 13, 27, and 37-43 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Dunphy, *et al.* in view of Kersey, *et al.* and Thomas, *et al.* and further in view of Ide (US Patent 5,382,097).

VII. Argument (37 C.F.R. §41.37(c)(1)(vii))

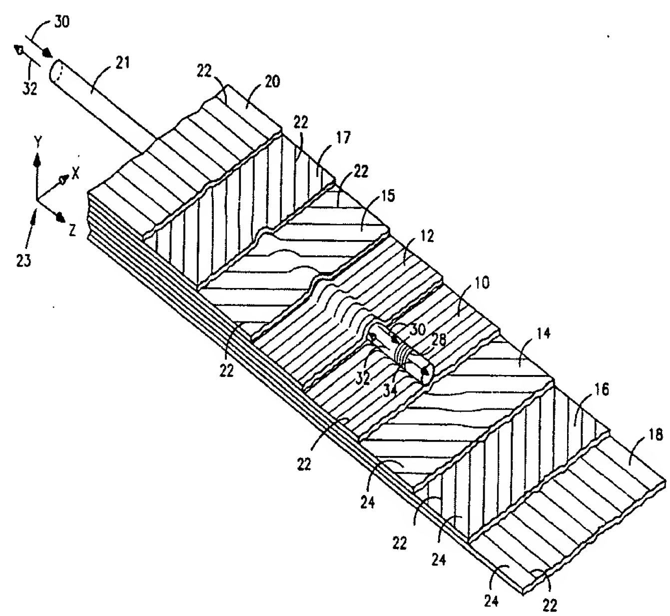
A. <u>Claims 1-12, 14-21, and 24-27 stand rejected under 35 U.S.C. §103(a)</u>

Claims 1-12, 14-21, and 24-27 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Dunphy, *et al.* (US 5,399,854) in view of Kersey, *et al.* (US 5,361,130) and Thomas, *et al.* (US 4,460,893). Withdrawal of this rejection is respectfully requested for at least the following reasons. There is no suggestion or motivation to combine Dunphy, *et al.*, Kersey, *et al.*, and Thomas, *et al.*

> To reject claims in an application under §103, an examiner must establish a *prima facie* case of obviousness. A *prima facie* case of obviousness is established by a showing of three basic criteria. First, ***there must be some suggestion or motivation***, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, ***to modify the reference or to combine reference teachings***. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. *See* MPEP §706.02(j) (emphasis added). The teaching or suggestion to make the claimed combination and the reasonable expectation of success ***must both be found in the prior art and not based on applicant's disclosure***. *See In re Vaeck,* 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991) (emphasis added). Furthermore, the mere fact that the reference can be modified does not render the modification obvious unless the cited art also

suggests the desirability of the modification. *In re Mills*, 916 F.2d 680, 16 USPQ2d 1430 (Fed. Cir. 1990).

With respect to independent claims 1, 16, and 24, neither Dunphy, *et al.,* Kersey, *et al.,* nor Thomas, *et al.*, provide motivation to combine teachings therein to create the subject invention as recited in these claims. Dunphy, *et al.* teaches an optical sensor that is embedded within a plurality of layers, wherein such layers include filaments that are aligned in a particular manner. For illustrative purposes, a figure of the embedded optical sensor of Dunphy, *et al.* is provided below.

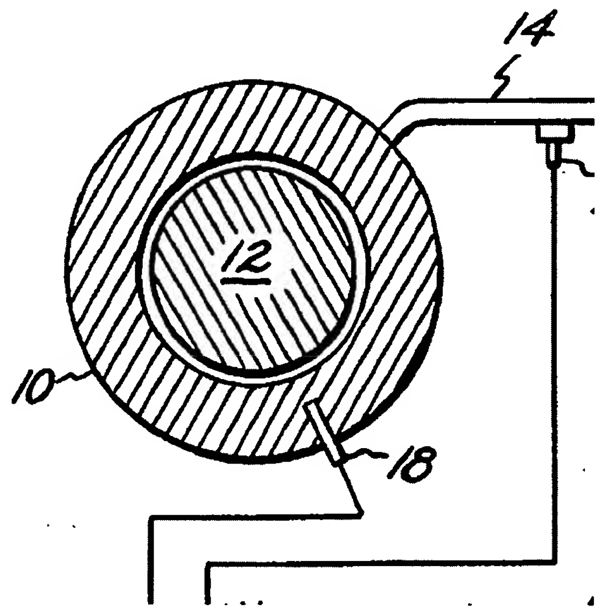


The Examiner has cited the above figure from Dunphy, *et al.* as illustrating "at least one optical fiber (21) embedded in a sample to be measured." As illustrated in the above figure and stated above, however in order to obtain a measurement the optical fiber (21) must be embedded in a plurality of layers (10), (12), (14), (15), (16), (17), (18), and (20). Furthermore, the aforementioned layers must include filaments (22) to enable the optical fiber (21) to be employed in connection with measuring stress, strain, temperature, *etc.* relating to the layers. Rendering the sensor still more complex, regions

of polymer matrix (24) must reside between the filaments, wherein such polymer matrix is described as "a thermal set epoxy resin." (*See* col. 4, lines 10-11). The filaments (22) and the polymer matrices (24) therebetween must be arranged in particular manners for the illustrated sensor to operate properly. (*See* col. 4, lines 33-46). Upon alterations of stress upon the sensor, a strong differential strain is imposed upon the optical fiber *via* the filaments, and a birefringence is induced within a portion of the optical fiber (*e.g.,* a grating (28)). Likewise, an alteration in temperature associated with the optical sensor induces birefringence within the optical fiber (21) *via* the filaments. This birefringence can be monitored to determine stress and/or temperature relating to the optical sensor generally, and more particular relating to the plurality of layers (10), (12), (14), (15), (16), (17), (18), and (20).

A plurality of layers, wherein such layers include a plurality of particularly arranged filaments, is not existent within bearings. Further, attempting to manufacture an inexpensive bearing while including layers with precisely arranged filaments would be extremely problematic. The above displayed figure and accompanying text in Dunphy, *et al.* describes an optical fiber (21) embedded within a plurality of layers, and <u>does not</u> teach or suggest that such optical fiber (21) can be ***embedded within a bearing*** as recited in independent claims 1, 16, and 24. More specifically, <u>nowhere</u> in Dunphy, *et al.* is there any mention of a bearing or any substantially similar manufacturing device.

The Examiner has cited Thomas, *et al.* to make up for deficiencies of Dunphy, *et al.* with respect to a lack of a bearing. Thomas, *et al.* discloses a system for detecting metal-to-metal contact in a journal bearing by placing a thermocouple "in close proximity to the maximum load-bearing point" in order to monitor temperature of the bearing (*See* col. 3, lines 32-44). Like Dunphy, *et al.,* Thomas, *et al.* provides no teaching, suggestion, or motivation to ***embed an optical fiber in a bearing*** as recited in the subject claims. Fig. 2 of Thomas, *et al.* is reproduced below for illustrative purposes.



A thermocouple (18) is mounted in a bearing (10) (which carries a rotating journal (12)) to monitor temperature of such bearing (10) proximate to a maximum load-bearing point. Oil is delivered through a supply conduit (14) based at least in part upon the temperature measured by the thermocouple (18). There is no mention anywhere in Thomas, *et al.,* however, that the thermocouple (18) can be replaced by an optical fiber, wherein the ***optical fiber provides a measuring system with information relating to at least one condition of a bearing*** as claimed.

To provide motivation for combining Dunphy, *et al.* and Thomas, *et al.,* the Examiner has stated "at the time of the invention, one of ordinary skill in the art would have replaced the sensor of Thomas with the fiber optic sensor of Dunphy in order to have a simpler sensor having a wider range of temperature measurement, and also measures temperature more accurately." The fiber optic sensor of Dunphy, *et al.,* however, is not "simpler" sensor when compared to conventional thermocouples – rather, an optical fiber must be embedded within a plurality of layers, wherein each of the layers includes a plurality of filaments that are aligned in a particular manner. Conventional thermocouples are cheap, interchangeable, have standard connectors and can measure a wide range of temperatures. Furthermore, prior to conception of the subject invention as

recited in the claims, there is no suggestion or motivation (within the cited references or as known to one of ordinary skill in the art) that an optical fiber is employable to provide precise temperature measurements (or other suitable measurements) while ***embedded within a bearing.***

Similarly, the cited references do not disclose, teach, or suggest ***an end of an optical fiber being flush with a contacting surface of a bearing.*** Further, there lacks motivation within the cited references to place ***an optical fiber flush with a contacting surface of a bearing*** as claimed. More specifically, positioning a thermocouple flush with a contacting surface of a bearing would render such thermocouple inoperable (as a required junction would wear). Therefore, while it may be desirable to place the sensor "in close proximity to the maximum load-bearing point", Thomas, *et al.* does not disclose, teach, or suggest that a sensor be placed ***flush with a contacting surface of the bearing*** as claimed. (*See* col. 3, lines 30-33). Moreover, Dunphy, *et al.* nowhere teaches that the disclosed optical sensor be placed ***flush with a contacting surface of a bearing*** as recited in independent claim 16. Accordingly, there is no motivation within the cited references to place ***an optical fiber being flush with a contacting surface of a bearing.***

Therefore, in view of at least the above, it is readily apparent that the rejection of independent claims 1, 16, and 24 (and dependent claims 2-11, 17-21, and 25-26, which respectively depend therefrom) should be withdrawn.

B. Claims 13, 27, and 37-43 stand rejected under 35 U.S.C. §103(a)

Claims 13, 27, and 37-43 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Dunphy, *et al.* in view of Kersey, *et al.* and Thomas, *et al.* and further in view of Ide (US Patent 5,382,097). Reconsideration and allowance of claims 13, 27, and 37-43 is respectfully requested for at least the following reasons. Claims 13 and 27 depend upon independent claims 1 and 24, which are believed to be in condition for allowance. Accordingly, this rejection is moot. Independent claim 37, like independent claims 1, 16, and 24, includes ***an optical fiber embedded in a bearing*** as an element. Ide is directed towards a thrust bearing that includes a carrier and a number of bearing pads supported in the carrier. Ide, like Dunphy, *et al.*, Kersey, *et al,* and Thomas, *et al.*, fails

to teach or suggest ***an optical fiber imbedded in a bearing*** as recited in independent claim 37. Accordingly, this rejection should be withdrawn.

C. Conclusion

For at least the above reasons, the claims currently under consideration are believed to be patentable over the cited references. Accordingly, it is respectfully requested that the rejections of claims 1-35 and 37-38 be reversed.

If any additional fees are due in connection with this document, the Commissioner is authorized to charge those fees to Deposit Account No. 50-1063.

Respectfully submitted,
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VIII. Claims Appendix (37 C.F.R. §41.37(c)(1)(viii))

1. (Original) A system for determining at least one condition of a bearing, comprising:

at least one optical fiber embedded in a bearing, the at least one optical fiber being adapted to transmit light from a light source; and

an interferometric system operatively coupled to the optical fiber and a processor;

wherein the interferometric system provides the processor with information relating to at least one condition of the bearing, and the processor determines a state of the at least one condition of the bearing based on the information.

2. (Original) The system of claim 1, wherein the processor determines rate of wear of the bearing based on the information.

3. (Original) The system of claim 1, wherein a length direction of the optical fiber is substantially parallel to a direction of wear of the bearing.

4. (Original) The system of claim 1, wherein the interferometric system generates a reference beam and a measuring beam from the light source, the measuring beam being transmitted through the optical fiber.

5. (Original) The system of claim 4, wherein the interferometric system generates an interference beam from a reflected reference beam and a reflected measuring beam.

6. (Original) The system of claim 5, wherein the interference beam includes at least one fringe, the at least one fringe corresponding to a change in length of the optical fiber.

7. (Original) The system of claim 6, further including a counter for counting the at least one fringe.

8. (Original) The system of claim 1, wherein the bearing is a ball bearing and includes at least one optical fiber in an inner race of the bearing at least one optical fiber in an outer race of the bearing.

9. (Original) The system of claim 1, wherein the bearing includes a plurality of optical fibers in the inner race of the bearing and a plurality of optical fibers in the outer race of the bearing.

10. (Original) The system of claim 1, wherein the at least one condition is wear of the bearing.

11. (Original) The system of claim 1, wherein at least one optical fiber is grated and coupled to a temperature sensor and the at least one condition is temperature environment of the bearing.

12. (Original) The system of claim 1, wherein at least one optical fiber includes microbends and is coupled to a pressure sensor and the at least one condition is the pressure environment of the bearing.

13. (Original) The system of claim 1, further comprising an actuator coupled to the processor and coupled to the interferometric system, the processor and the actuator cooperating to maintain a fixed fringe pattern based on readings the processor receives from the interferometric system.

14. (Original) The system of claim 1, wherein the bearing is one of a sleeve bearing, a hydrodynamic bearing, a double row ball bearing and a thrust bearing.

15. (Original) The system of claim 1, wherein the at least one optical fiber comprises a plurality of optical fibers sharing the interferometric system and the processor.

16. (Original) A system for determining at least one condition of a bearing, comprising:

a light source for generating a beam of light;

at least one optical fiber at least part of which is embedded in a bearing, the at least one optical fiber having first and second ends, the first end receiving the beam of light, the second end being flush with a contacting surface of the bearing; and

a measuring system operatively coupled to the optical fiber;

wherein the optical fiber provides the measuring system with information relating to the at least one condition of the bearing.

17. (Original) The system of claim 16, the measuring system includes an interferometric system and a processor.

18. (Original) The system of claim 16, wherein a length direction of the at least one optical fiber is substantially parallel to a direction of wear of the article

19. (Original) The system of claim 16, wherein the at least one condition is wear of the bearing.

20. (Original) The system of claim 16, wherein at least one optical fiber is grated and coupled to a temperature sensor and the at least one condition is temperature environment of the bearing.

21. (Original) The system of claim 16, wherein at least one optical fiber includes microbends and is coupled to a pressure sensor and the at least one condition is pressure environment of the bearing.

22.-23. (Canceled)

24. (Original) A method for determining at least one condition of a bearing, comprising the steps of:

providing a bearing having an optical fiber embedded therein;

using a measuring system operatively connected to the optical fiber to collect information relating to the optical fiber; and

using a processor operatively coupled to the measuring system to determine the at least one condition of the bearing based on the information.

25. (Original) The method of claim 24, the at least one condition being bearing wear rate.

26. (Original) The method of claim 24, the at least one condition being bearing temperature environment.

27. (Original) The method of claim 24, the at least one condition being bearing pressure environment.

28.-36. (Canceled)

37. (Original) A system for determining at least one condition of a bearing, comprising:

at least one optical fiber embedded in a bearing, the at least one optical fiber being adapted to transmit light from a light source;

an interferometric system operatively coupled to the optical fiber and a processor, the interferometric system comprising optics and a detector, the light source transmitting light from the light source to the at least one fiber which is reflected from the optics to the detector;

an actuator coupled to the processor and the optics wherein the processor controls the actuator to adjust the optics based on at least one condition of the bearing.

38. (Original) The system of claim 37, the processor further providing at least one of diagnostics and prognostics information.

39. (Original) The system of claim 37, further comprising a plurality of interferometric systems each coupled to a processor wherein each of the plurality of interferometric systems employ the light source utilizing an optical coupler to split the light from the light source to the plurality of interferometric systems.

40. (Original) The system of claim 37, the at least one optical fiber comprising a plurality of optical fibers embedded in a plurality of devices, the plurality of optical fibers sharing the light source, the interferometric system and the processor.

41. (Original) The system of claim 37, the at least one optical fiber comprising a plurality of optical fibers measuring a plurality of condition of the bearing, the plurality of conditions being combined using sensor fusion to provide an output of at least one of health state, fault condition, control action, warning and recommendation action.

42. (Original) The system of claim 37, the at least one optical fiber, the light source, the interferometric system, the processor, the detector, the actuator being integrated into the bearing to form a smart bearing.

43. (Original) The system of claim 37, wherein the bearing is a babbitt and the processor predicts when the babbitt needs to be replaced.

IX. Evidence Appendix (37 C.F.R. §41.37(c)(1)(ix))

None.

X. Related Proceedings Appendix (37 C.F.R. §41.37(c)(1)(x))

None.